Claims:

SUB A1

1. An auditory screening device, comprising:

a portable hand-held enclosure;

a signal processor housed by said enclosure, said processor having a computer program operated on command by a user, said program producing auditory tests selected from the group comprising otoacoustic emission (OAE) test procedures, auditory brainstem response (ABR) test procedures, tympanometry, otoreflectance and combinations thereof for a test subject;

a display device mounted to said enclosure, said display device being operatively connected to said signal processor, said display device displaying the results of the selected test in real time;

a connection point on said enclosure for a probe, the connection point being operatively connected to said signal processor; and

a power supply for operating the signal processor.

2. The screening device of claim 1 further including a plurality of electrodes for collecting data from a patient, said electrodes being operatively connected to said signal processor.

3. The device of claim 2 further including a tympanometry interface operatively connected to said signal processor for recording middle ear pressure on a test subject and adjusting minor middle ear conditions during OAE and ABR testing.

4. The device of claim 3 further including an otoreflectance interface operatively connected to said signal processor for recording assessing middle ear conditions on a test subject.

5. The device of claim 4 further including an OAE simulator interface operatively connected to said signal processor for testing the integrity of an OAE system.

6. The device of claim 5 further including an infrared interface operatively connected to said signal processor for permitting communication between said signal processor and an external device.

7. The device of claim 6 further including a memory subsystem operatively connected to said signal processor.

8. The device of claim 7 further including a memory mapped input/output device operatively connected to said memory subsystem and to said signal processor, said display being operatively connected to said signal processor through said memory mapped device.

9. The device of claim 8 further including a keyboard, said keyboard being operatively connected to said signal processor through said memory mapped device.

10. The device of claim 9 wherein said power supply is rechargeable.

11. The device of claim 1 wherein said signal processor performs a time domain sum and average over time for obtaining OAE signal detection using a frame overlap method.

12. The device of claim 11 wherein said memory subsystem includes provisions for patient data.

13. The device of claim 12 wherein the ABR test signal is determined by digital signal processing and counting zero crossings of correlated internally generated sinusoids.

14. A method of conducting an OAE audio test, comprising the steps of inserting a probe in a patient's ear, the probe including a speaker and a microphone;

connecting the probe to a hand-held device;

generating an auditory signal in the hand-held device;

detecting auditory signals generated in the ear via the microphone;

converting the analog signals to digital signals;

storing the incoming data in a new frame buffer;

sizing the new frame buffer so that it is an integer number of samples of two primary tones and frequencies f_1 and f_2 and also an integer number of samples of the tone produced by the ear defined by the frequency f_{dp};

passing the data from a single frame to a discrete Fourier transform process to calculate the frequency specific magnitude and phase content of the signal;

comparing the magnitude and phase to a table to detect whether to reject the data, discard the data but update a noise table, or accept the data;

saving a copy of the frame data;

sliding the date frame by a predetermined amount;

collecting the data over a predetermined number of frames;

averaging the data;

converting the data to frequency domain; and

displaying the data to a user in a hand-held device in real time.

15. The method of claim 14 further including the step of saving the data internally of the device.

16. The method of claim 15 further including the step of sending to the user an indication of the subject passing or failing the test.

17. The method of claim 16 further including the step of transferring the data from the device to a second external unit.

18 An auditory screening device comprising;

a hand-held enclosure;

a signal processor within said enclosure;

a memory module within said enclosure operatively connected to said signal processor;

a display screen mounted to said enclosure, said display screen being operatively connected to said signal processor;

a computer program at least partial contained in said signal processor, said computer program being accessible by a user to perform an otoacoustic emission test and an auditory brainstem response test for a test subject, said memory module maintaining a plurality of test subject records for display on said display screen;

19. The screening device of claim 18 further including a keyboard for accessing said computer program.

20. The device of claim 19 wherein the OAE information is recorded by frames, and information from a preceding frame is used in connection with information of a succeeding frame to reduce the signal to noise level in the received signals.

21. The device of claim 20 wherein the amount of information employed with a succeeding frame is obtained from the formula:

$$M = \left(\frac{f_n}{f_s - 1}\right) \times \left(\frac{f_s}{f_{dcl} + 1}\right)$$

where M equals overlap number, f_n equals frame number, f_s equals frame size and f_{dcl} equals frame data cycle length.

22. The device of claim 21 wherein said computer program further includes tympanometry test procedures conducted independently or in conjunction with OAE and ABR tests. .

23. The device of claim 22 wherein the computer program determines data information for the brainstem response test by counting zero crossing of a sinusoid.

24. A method of conducting an OAE otoacoustic test in which reduced signal to noise ratio is obtained by:

receiving OAE signal information in frames;

overlapping information from a proceeding frame for use in connection with information from a succeeding frame;

making a determination to accept the data, reject the data, but update noise average or discard the data based upon predefined parameters.

25. The method of claim 24 wherein an overlap is determined from the formula:

$$M = \left(\frac{f_n}{f_s - 1}\right) \times \left(\frac{f_s}{f_{dcl} + 1}\right)$$

where M equals overlap number, f_n equals frame number f_s equals frame size, and f_{dcl} equals frame data cycle length.

26. The method of claim 25 further including the step of conducting an auditory brainstem response (ABR) test for a test subject.

27. The method of claim 26 wherein data for the ABR test is obtained by counting zero crossings of an internally generated, correlated sinusoid.

28. An auditory screening device comprising:

a portable hand-held enclosure;

a signal processor housed by said enclosure;

said processor having an OAE simulator program at least partially contained in said processor; said processor generating simulated f_{dp} tones in response to tones generated by an ear probe; and

an ear probe interface operatively connected to said processor.